Infrared Spectroscopy of High-Tc Superconductors in High Magnetic Field

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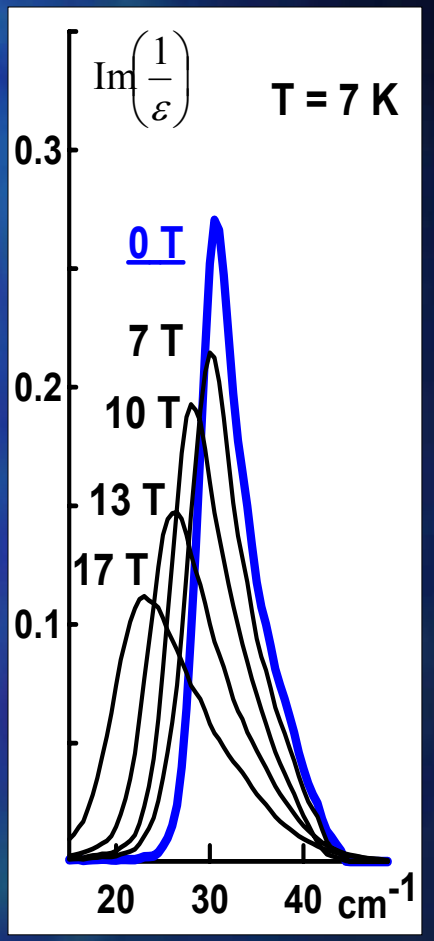
A rich variety of quantum liquids, including superconductors, liquid helium, atom Bose-Einstein condensates and possibly even excitons in semiconductors exhibit macroscopic coherence in the form of ordered arrays of vortices. With the advent of high-T_c superconductors it became possible to study universal patterns of the vortex matter in the regimes not readily attainable in other superconducting systems. The PI has focused on the systematic examination of the so-called Josephson vortex state realized in high-T_c systems when the magnetic field is oriented parallel to conducting CuO_2 planes using the technique of infrared (IR) spectroscopy. IR response in relatively small magnetic fields (typically H<7 T) appears to be in accord with the existing models of vortex dynamics. By extending previous studies to stronger fields (up to 17 T) we found marked departures of the experimental data from conventional Josephson vortex theory. In particular the superfluid density in $La_{2-x}Sr_xCuO_4$ crystals revealing static ordering of spin stripes appears to be much more fragile than the models prescribe. These results have been quantitatively explained in terms of the depression of the superconducting order parameter triggered by the formation of stripes [S.V. Dordevic, et al. Europhysics Lett 61, 122 (2003)].

In a closely related study the PI proposed a novel experimental technique: Josephson plasmon microscopy [S.Dordevic, et al. PRL 91, 167401, (2003).] The unique feature of this technique is in its ability to probe spatial non-uniformity of superconducting condensate that cannot be readily accomplished by any other method. Currently this tool with unparalleled capabilities to explore spatially inhomogeneous condensate is applied to the analysis of the IR data in the vortex state.

$La_{2-x}Sr_xCuO_4$



Evolution of the Josephson plasmon in the loss function spectra taken in high magnetic field. The asymmetric form of the loss function is characteristic of spatially inhomogeneous superconducting state.

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Educational and outreach activities.

Funding from this and previous NSF awards has facilitated training of **12** undergraduate students, **5** graduate students and **2** postdoctoral research associate. These individuals received training in spectroscopic studies of complex materials.

The PI is an active participant of the UCSD program providing research experience to undergraduates with the special emphasis on diversity. Many of the undergraduate students working with the PI since 1998 have chosen to continue training in physics and are now enrolled in top graduate programs. One of the undergraduate students has received the prestigious Hertz fellowship.

Starting from the Summer of 2004 the D.N. Basov will serve as the PI on the NSF-funded REU program at the UCSD physics department.

UCSD spectroscopy team is aligning optics for infrared experiments on a high-Tc superconductor in high magnetic field. From left to right: Kenneth Burch (undergraduate student), Sasa Dordevic, Jason Singley and William Padilla (all graduate students). An original scheme for coupling an infrared interferometer to the magnet (blue cylinder in the left of the photograph) has been designed and implemented by Willie Padilla.